Photo courtesy of Doug Wellumson, Arkdale Lake

ARKDALE LAKE MANAGEMENT PLAN

APPROVED 5/09 BY WDNR

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PROCEDURE FOR MODIFYING LAKE MANAGEMENT PLAN

The Arkdale Lake Association will maintain an agenda item of "modifying lake management plan" on its meeting notices. Although suggested changes or additions can be presented at any time, they will only be acted upon at the annual meeting.

BASELINE INFORMATION

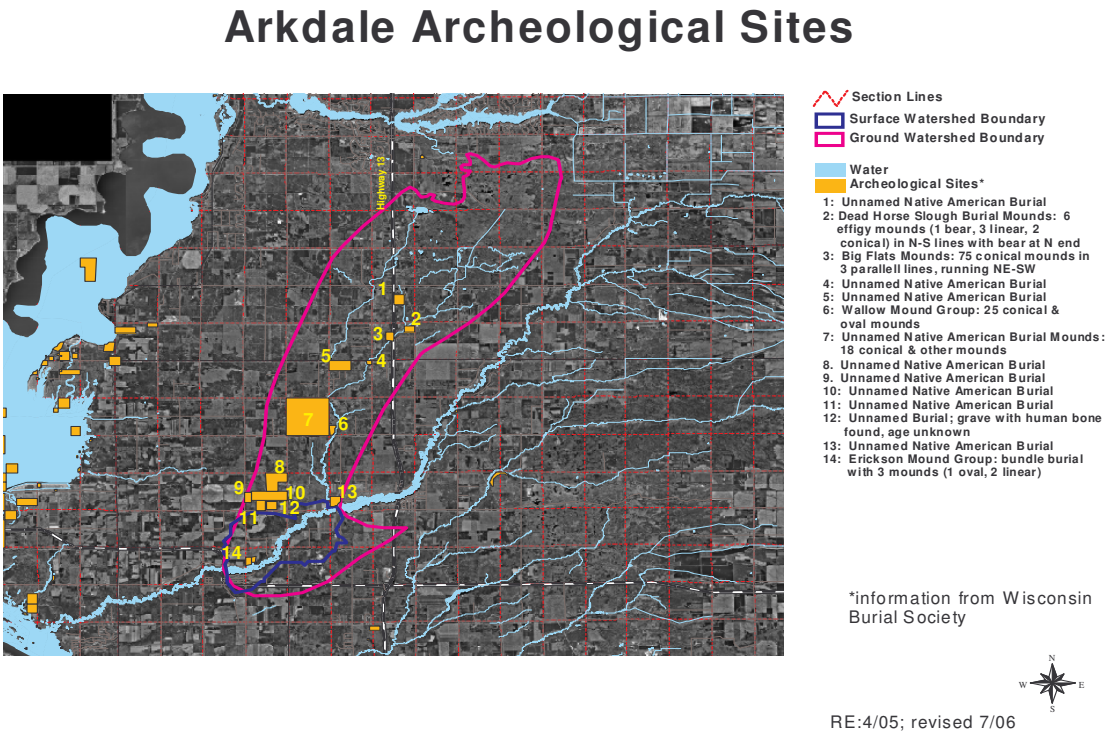
Arkdale Lake is located in the Town of Strongs Prairie, Adams County, WI, in the south central part of Wisconsin. It is reached off of Highway 21. Arkdale Lake is a mildly eutrophic impoundment (man-made lake) with fair to good water quality and fair water clarity. It was created by a dam on Big Roche a Cri Creek. The dam is owned and operated by the Arkdale Lake Association. The lake is a few miles downstream of Big Roche a Cri Lake, a larger impoundment of Big Roche a Cri Creek. Ultimately, Big Roche a Cri Creek spills into the Wisconsin River. There are public boats ramps on the north and south and west sides of the lake.

According to the Wisconsin Department of Natural Resources (WDNR), the lake has 56 surface acres, with a maximum depth of 8 feet and an average depth of less than 5 feet. However, a bathymetric map of Arkdale Lake was produced in 2007, after measurements taken in 2006. That field survey found that the lake, with islands, is just under 48 surface acres (47.77). The maximum depth, found at the far east end of the lake at one of the lake/creek intercepts, was 10.5 feet. In the main body of the lake, the maximum depth is less than 8 feet. 46.6% of the lake has a depth of 3 feet or less.

Although the surface watershed for Arkdale Lake is quite small, its ground watershed is large, extending several miles north of the lake. Additionally, the lake is part of the very large Big Roche a Cri Creek Watershed that extends eastward into Waushara County. The lake has a history of dense aquatic vegetation throughout the lake and increasingly shallow depths.

There are several reported archeological sites in the watersheds, including several Native American burial mound groups. Both federal and state laws prohibit further disturbance of these sites without permission of the federal government and input from the local tribes.

Figure 1: Archeological Sites



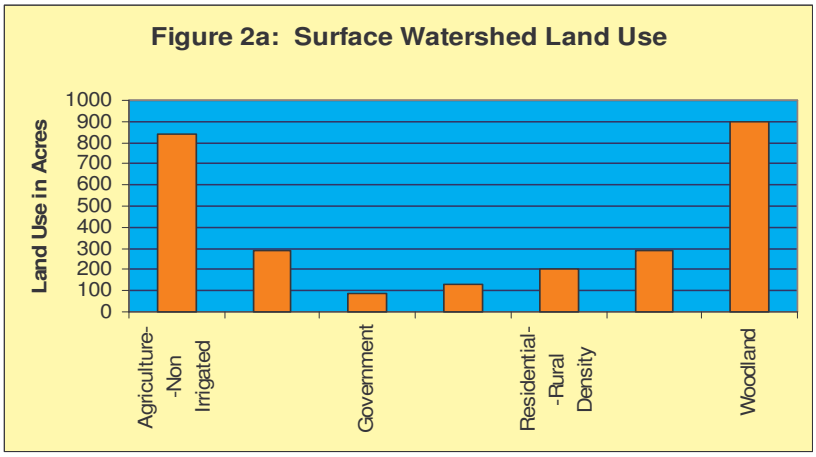
Land Use in Surface and Ground Watersheds

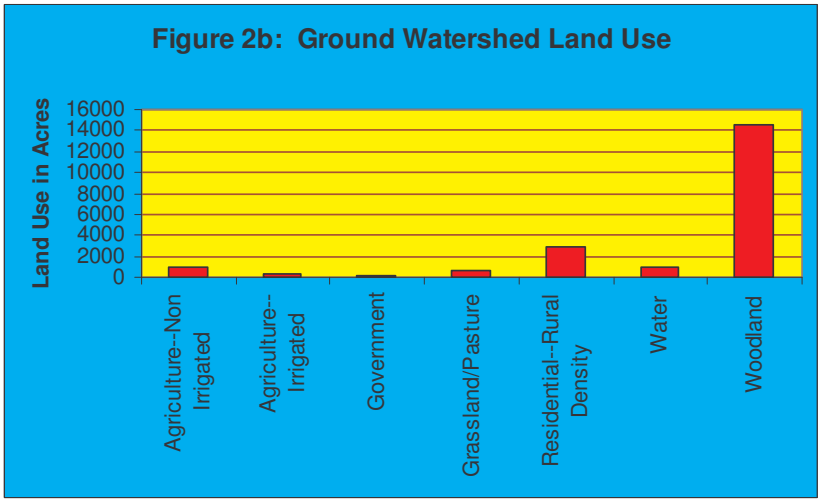
Land Use is very important in looking at ways to maintain or improve water quality. Studies have shown that types of land use affect sedimentation rate, erosion rate and runoff rate (with included pollutants). Increased sedimentation can not only fill in shallow areas of water, but also causes excessive turbidity that harms aquatic life by destroying habitat and smothering oxygen. Increased runoff carries with it pollutants besides sediments, including pathogens, nutrients that affect algal & aquatic plant growth (nitrogen & phosphorus), pesticide residue, fertilizer chemicals, organic matter, metals, petroleum products and road salt. Increased runoff can also reduce ground water recharge and increase shore erosion. Addition of such substances not only degrades water quality and habitat, but also limits aesthetic and recreational enjoyment.

Studies also suggest that an increase in impervious surface around a waterbody of 20% may negatively impact water quality. Impervious surfaces include areas such as pavements, roofs, decks, sidewalks, compacted soil, cement patios, etc. Similarly, traditional closely-mowed lawns, as opposed to unmown lawns or native vegetation, tend to have high runoff rates and low infiltration rates. Soil types may also influence runoff amounts. Research in Indiana established the difference in

average runoff amounts, based on land use. Runoff from general residential (i.e., not necessarily highly-developed) was twice as much as runoff from forested land. Runoff in highly-developed areas may be up to fourteen times more than forested lands and twice as much as from agricultural lands. With a highly-developed residential shore, residential runoff at Arkdale Lake will be one of the main negative impacts on its overall water quality in the future if steps are not taken to address this problem.

The Adams County Land & Water Conservation Department conducted a land use evaluation for both the ground and surface watersheds of Arkdale Lake in 2004. The three largest surface watershed land use were woodlands (32.80%), non-irrigated agriculture (30.77%) and irrigated agriculture (10.53%). The ground watershed was dominated by woodland use (66.32%), followed by rural residential (13.14%) and non-irrigated agriculture (7.61%).





Nearly 31% of the surface watershed for Arkdale Lake is non-irrigated agriculture. Agriculture may contribute significantly to the amount of nutrients in water. It is important to reduce this contribution as much as possible.

The largest land use category in the Arkdale Lake's surface and ground watersheds is woodlands. Since forest floors are often full of leaves, needles and other duff, runoff from forested lands may be more filtered than runoff from agricultural or residential lands.

Residential land use comprises 12.13% of the surface watershed and 13.92% of the ground watershed, especially around the lake itself. This land use category may also contribute nutrients to the water from stormwater runoff, mowed lawns and impervious surfaces. This nutrient source should also be reduced as much as possible.

There are significant wetlands at each end of Arkdale Lake. Wetlands play an important role in water quality by trapping many pollutants in runoff waters and by serving as buffers to catch and control what would otherwise be uncontrolled water and pollutants. Wetlands also play an essential role in the aquatic food chain, thus affecting fishery, and also serve as spaces for wildlife habitat, wildlife reproduction & nesting, and wildlife food. It is essential to preserve these wetlands, especially those just upstream of the lake, for the water quality in Arkdale Lake.

Figure 3: northeast end of Arkdale Lake

Land Use--Arkdale Lake Surface Watershed

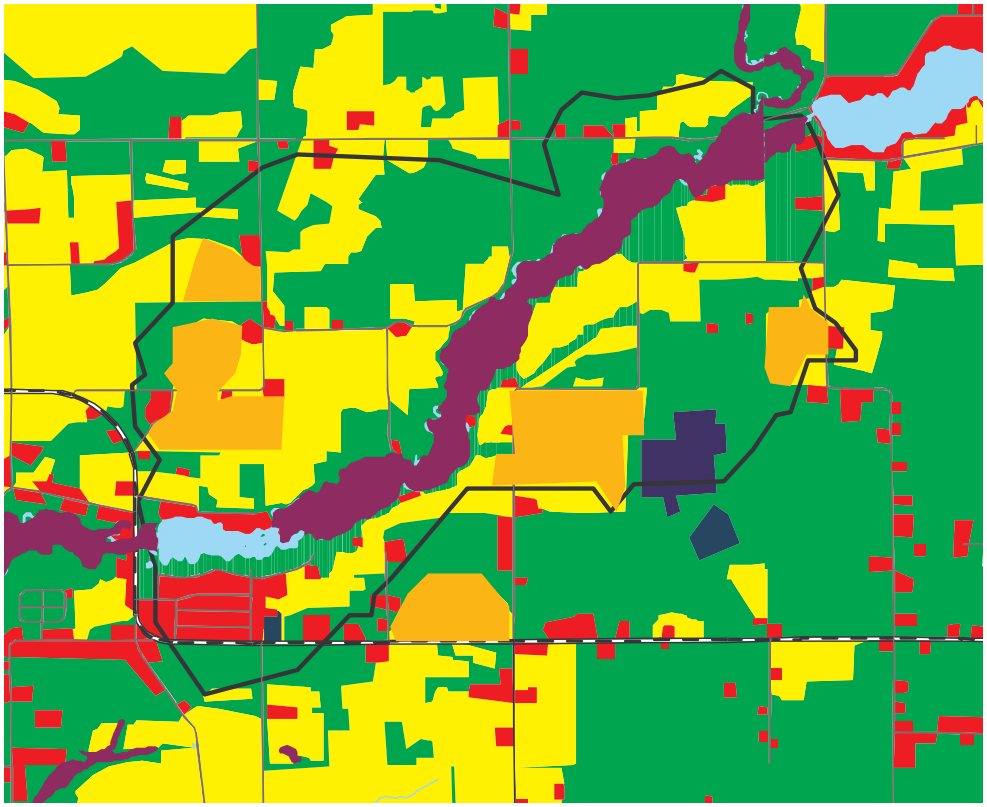


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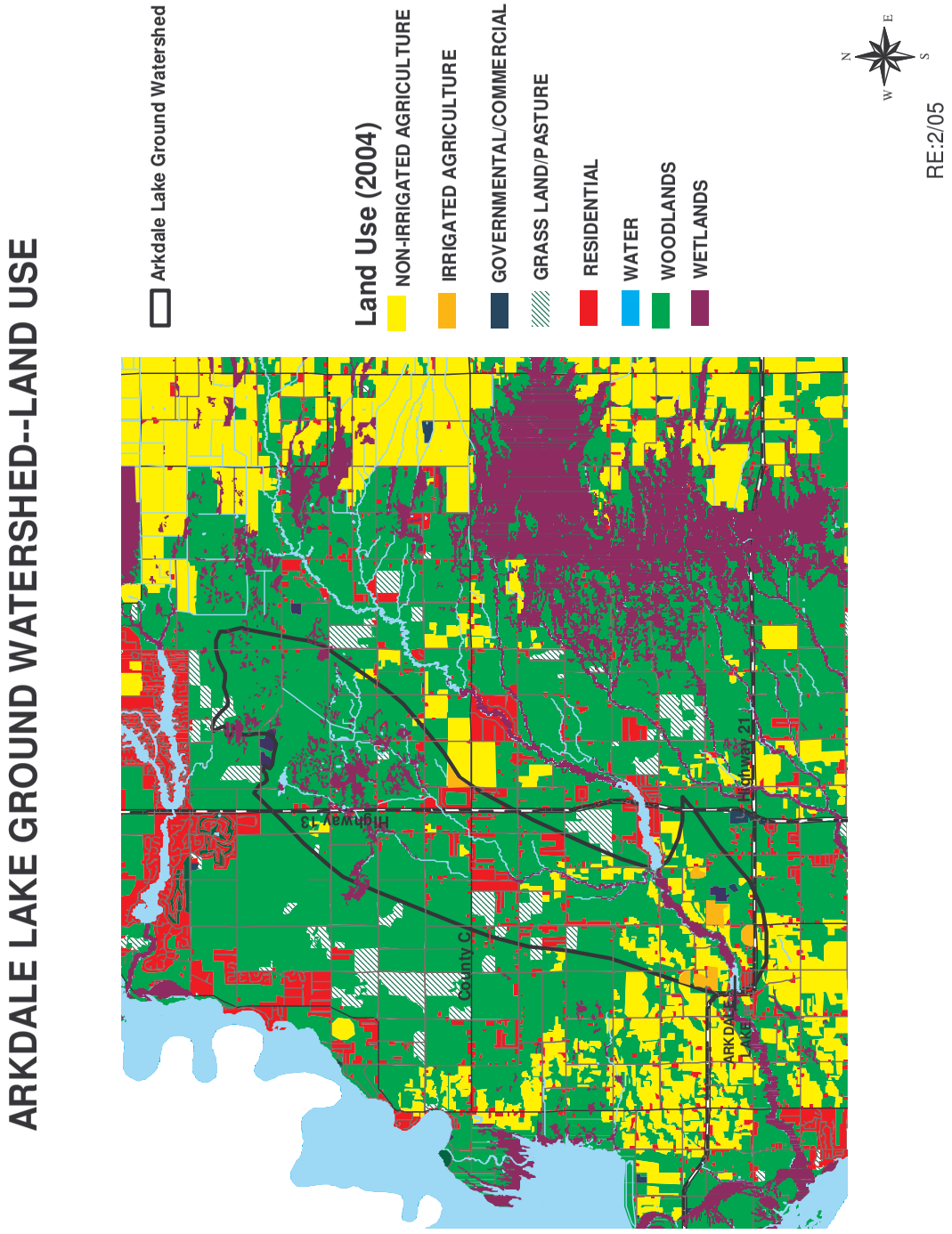
Figure 4a: Surface Watershed Land Use Map

Figure 4b: Ground Watershed Land Use Map

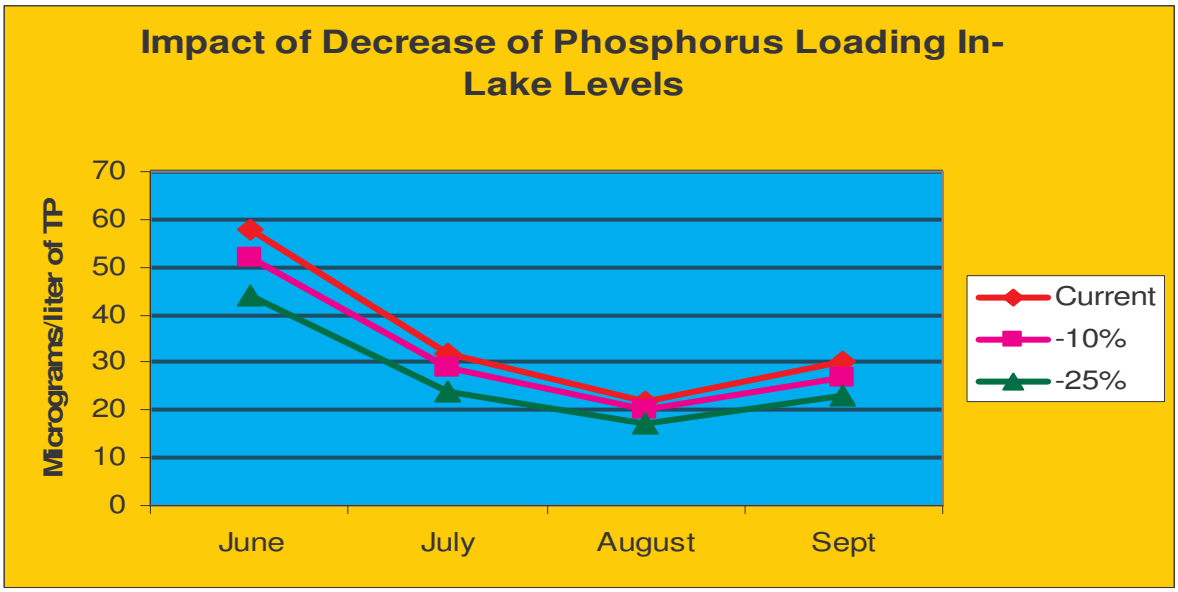


According to phosphorus-loading modeling done by the Adams County Land & Water Conservation Department, the upstream watershed of Big Roche a Cri Creek contributes 68.5% of the phosphorus to Arkdale Lake. Some phosphorus loading, such as that from woodlands or other water surfaces, is not controllable by humans; however, some of the phosphorus loading from residential and agricultural inputs is controllable. Residential practices such as not using lawn fertilizers, installing native vegetation and/or unmowed buffers and controlling runoff from impervious surfaces can reduce phosphorus input. Agricultural practices such as conservation tillage, increased residue and field buffers can reduce agricultural phosphorus input.

Big Roche a Cri Lake previously developed a lake management plan that included reducing phosphorus loading around that lake's shore and in the large watershed that feeds it. If that lake is successful, there will be significant decreases in phosphorus in Arkale Lake. If Arkdale Lake watershed residents take steps to decrease phosphorus loading around the lake, there would be an even larger decrease of phosphorus loading.

Even slight decreases in the phosphorus input from agriculture, residential and septic land use could make a big difference in phosphorus loading into Arkdale Lake. A 10% decrease in these loads would reduce in-lake phosphorus by 3 to 6 micrograms/liter, depending on the month. A 25% reduction of human impact could reduce the amount of phosphorus in the lake by 3 to 19 micrograms/liter.

Figure 5: In-Lake Phosphorus Changes from Decrease



Public Use and Value

In 2007, the Arkdale Lake Association conducted a mailed citizen survey about lake issues to landowners in both the surface and ground watersheds. 38.7% of the respondents were full-time residents. The average time respondents had owned their land was 13.1 years. The main two reasons respondents had chosen to purchase land in the Arkdale Lake vicinity were proximity (74.2%) and beauty of the location (54.8%). 41.9% of the respondents use the lake property as their retirement home (all respondents were over 40 years old).

The most common activities around the lake engaged in by the respondents were fishing (64.6%), kayaking/canoeing (41.9%), pleasure boating (38.7%), and bird watching (35.5%). Concerns were expressed about the level of weed growth, the number of geese on the lake, and increased sedimentation (reducing the lake depth) seeming to come into the lake from Big Roche a Cri Creek.

Respondents were asked to identify their opinion of causes of pollution to the lake. Top five identified were agricultural fertilizers/pesticides; manure from farm animals; soil from farm fields, lawn/urban fertilizers/pesticides; and grass clippings/leaves. Significant concern was also expressed about the silting/sedimentation of the lake from upstream input and additional pollutants that may be flowing from the upper watershed. Respondents felt the lake has been getting shallower and shallower due to the uncontrolled input from the upstream watershed.

Although over 60% of the respondents recognized that shore buffers are good for water quality, many also valued a "well-maintained lawn to the shoreline" (41.9%). Respondents felt that a well-maintained turf lawn increases property value (58.1%), and 96.8% of the respondents felt their neighbors valued a well-maintained lawn. 71% valued how their lawn looked and 45.2% cared what their neighbors thought about their lawn.

Soils in the Watershed

Loamy Sand is the most common soil type in the ground watershed (62.8%), followed by Sand (29.3%). However, the surface watershed is dominated by Sand (66.3%), seconded by Loamy Sand (26.9%).

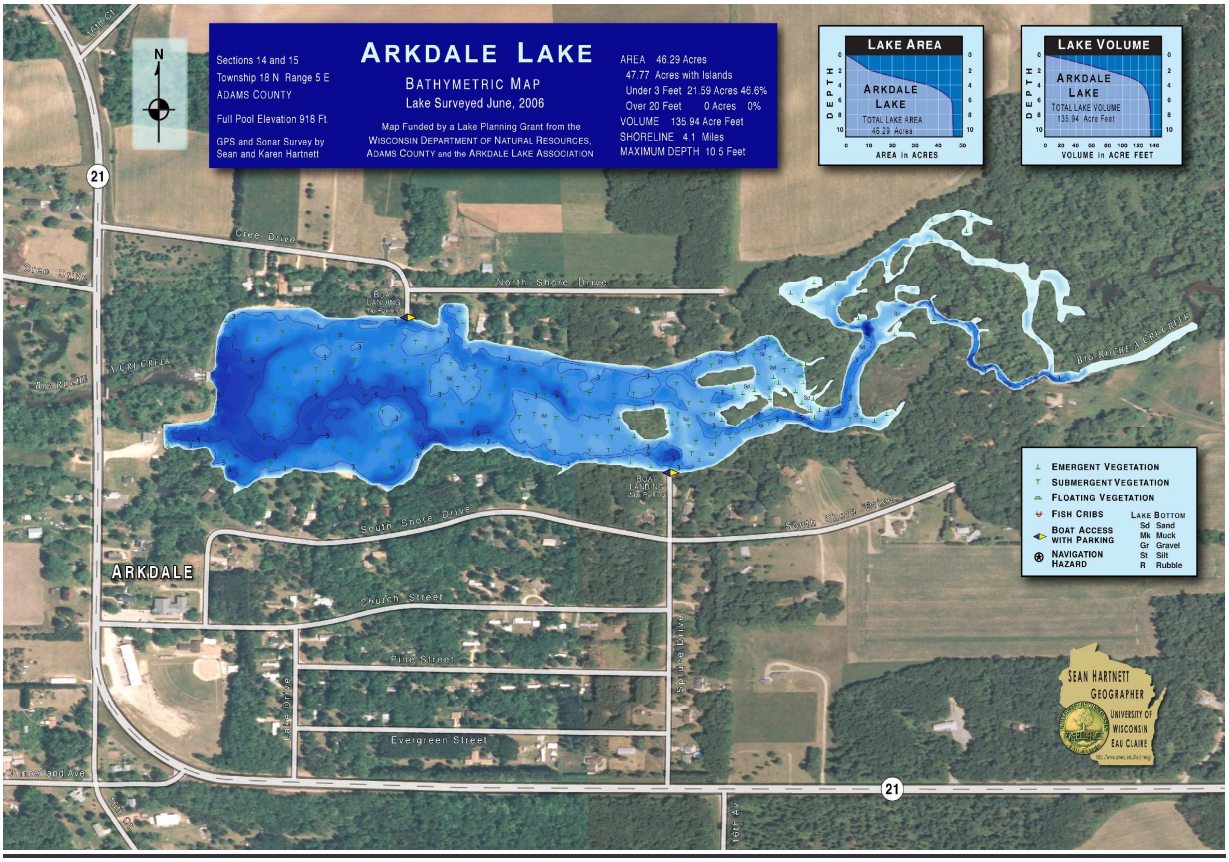
Sands and Loamy Sands are generally well-drained to somewhat excessively drained, with moderate to rapid permeability in the surface layer and slow to rapid permeability in the subsurface layers. Land runoff is slow to rapid, mostly depending on slope. Available water capacity ranges from usually low, as is natural fertility organic matter content. There are wide ranges of suitability for cropping, tree-production and engineering uses. Most of these soils have erosion, blowing and drought hazards as well. Depth to groundwater is mostly over 20', although there are some areas of perched water tables. Bedrock is mostly sandstone.

Lake Basin Shape

Arkdale Lake is a narrow shallow basin that gradually slopes over most of the lake. It is situated roughly east to west, with an irregular shore and meandering streams and wetlands at both end of the lake. As noted earlier, the lake is very shallow, with sunlight reaching the entire lake bottom (see Figure 5). The dam is located at the west end of the lake. There are small areas of steeper slopes near the dam and on the southeast side of the lake. When those factors are added to the overall very shallow aspect of the lake, plant growth is highly favored in Arkdale Lake.

According to the 2005 aquatic plant survey, soft sediments covered 68.75% of the littoral zone in Arkdale Lake (most of the lake could be called a littoral zone). The richness or sterility and texture of sediment affect the type and abundance of aquatic species in a location. In soft sediments like those covering much of the bottom of Arkdale Lake, nutrient availability is high, creating a favorable condition for aquatic plant growth, especially when coupled with the ability of sunlight to reach the entire lake bottom, further encouraging aquatic plant growth.

Figure 6: Arkdale Lake Depth Map (2006)



Lake Chemistry

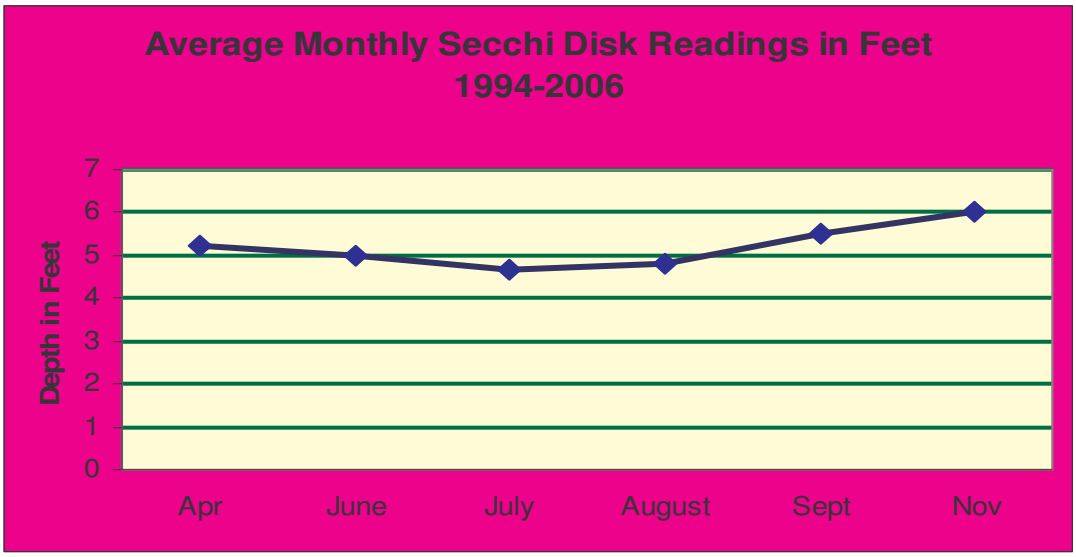
One indicator of water quality is a lake's trophic status, an index for measuring a lake's nutrient status. Oligotrophic lakes have clear, often cold, water with low overall productivity and very desirable fisheries of large game fish. Eutrophic lakes have poor water clarity, with high production of plants and frequent algal blooms likely. Eutrophic lakes also may have fish kill histories due to oxygen depletion and often have rough fish, such as carp, that contribute to the "muddiness" of the lake water. Mesotrophic lakes are those in between oligotrophic and eutrophic lakes, with more production and accumulated organic matter than oligotrophic lakes, but only occasional algal blooms, and a good mixed fishery.

There are three lake chemistry readings that Wisconsin has traditionally used to determine a lake's trophic status. These are Secchi disk readings, which test water clarity; total phosphorus level, which indicates the amount of phosphorus available for aquatic plant and algae production; and cholorophyll a, which correlates to algal blooms. These measurements were taken several times by Adams County

Land & Water Conservation Department from 2004 to 2006. In 1994, WDNR staff also took a few water samples from Arkdale Lake. And in 2007, a citizen monitoring program started on Arkdale Lake, taking a series of water quality measurements.

Secchi Disk Readings: Secchi disk readings taken in Arkdale Lake over the years have generally been fair. The average growing season (May-September) water clarity for 1994 was 6.25 feet; for 2004, it was 5.5 feet; for 2005, it was 5 feet; for 2006, it was 5.13 feet; and for 2007, it was 6.25 feet.

Figure 7: Secchi Readings 1994-2006

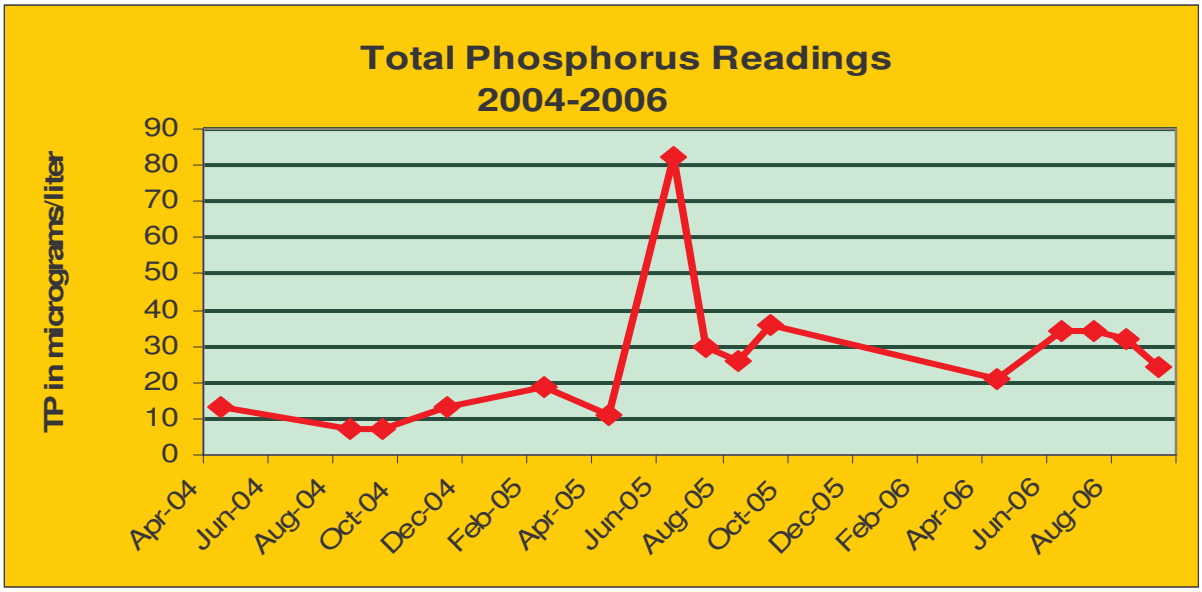


Total Phosphorus Readings: In 1994, the WDNR tested Arkdale Lake's phosphorus level three times, taking separate surface and bottom measurements. For that year, the average growing season total phosphorus for the surface layer was 29.5 micrograms/liter; for the bottom, it was 24 micrograms/liter.

The Adams County Land & Water Conservation Department also took water samples from deep in the lake and at the surface separately. In 2005, the bottom average total phosphorus was 45 micrograms/liter; the top was 36.2 micrograms/liter. Both figures went down slightly in 2006, with the bottom registering a growing season average of 39.8 micrograms/liter of total phosphorus and the top averaging 28 micrograms/liter. Only two surface total phosphorus readings were taken in 2007 during the growing season—the average was 25.9

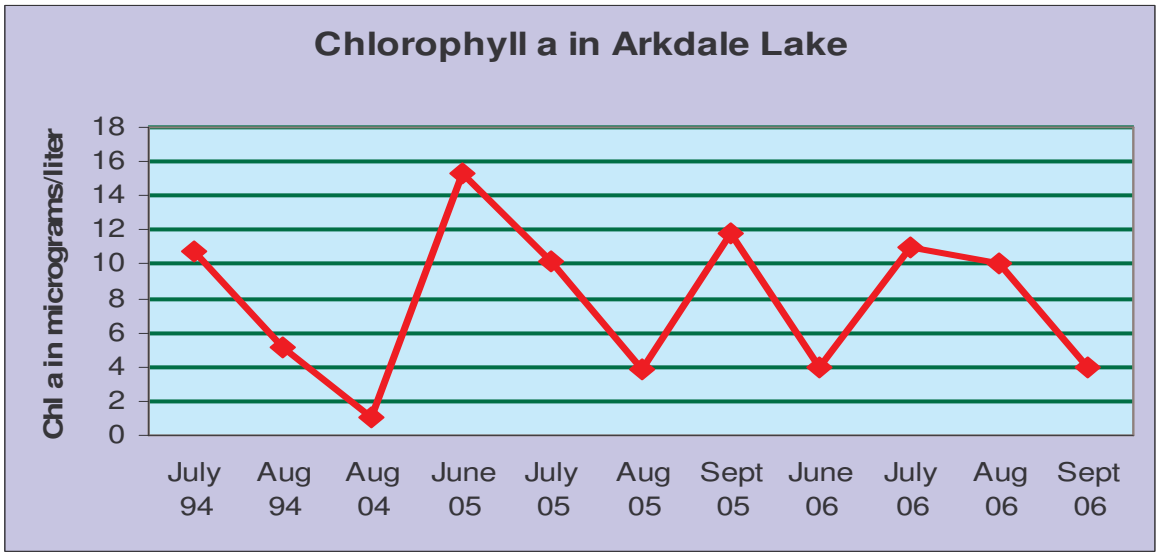
micrograms/liter. Averages for the water column for each data are shown in Figure 7.

Figure 8: Total Phosphorus Readings



Chlorophyll a: Chlorophyll a is the third factor often used in evaluating water quality, since studies have shown it is correlated with algal bloom frequency. The WDNR did take three Chlorophyll a readings in 1994 for Arkdale Lake between July and September, averaging 6.56 micrograms/liter. Adams County LWCD's average Chlorophyll a readings were: for 2004, 4.8 micrograms/liter; for 2005, 4.1 micrograms/liter; and for 2006, 5.25 micrograms/liter.

Figure 9: Chlorophyll-a Readings 1994-2006



The waters of Arkdale Lake tend to be very slightly acidic at the bottom (average 7.2), with pH readings rising as the surface nears to an average of 7.5 at the surface. The lake has moderately hard water with sufficient alkalinity to protect its fishery from the effects of acid rain or other acidic deposits. Hard water lakes tend to have clearer water and more diverse fishery than soft water lakes. Perhaps because Arkdale Lake is so shallow, the bottom of the lake does not tend to get hypoxic (low in oxygen) as the summer goes on. There appears to be sufficient oxygen for the fish present, even without aerators.

Readings for sodium, chloride, magnesium, sulfate and potassium in Arkdale Lake's waters have all been low, below any caution levels. All of the turbidity results have also been less than 5 NTUs, so there do not appear to be turbidity issues that could affect plant growth and fish survival.

A problem that may need to be dealt with is aging septic systems. Of the 2007 survey respondents, the average septic system around the lake had been installed before 1992, thus relieving them of the regular inspection/pumping requirements of Comm 83. The average septic system size was just under 1000 gallons (988).

The three "trophic" parameters suggest that Arkdale Lake is a mildly eutrophic lake, maintaining fair water clarity, fair total phosphorus levels and good Chlorophyll a readings. Arkdale Lake thus scores 54 TSI on Secchi Disk readings; 51 on Chlorophyll a readings; and 53 TSI on Phosphorus Levels, for an average TSI reading of 52, placing it in the "mildly eutrophic" class overall, slightly below the county impoundment trophic state index of 52.83.

Figure 10: Arkdale Trophic Status Index Graph

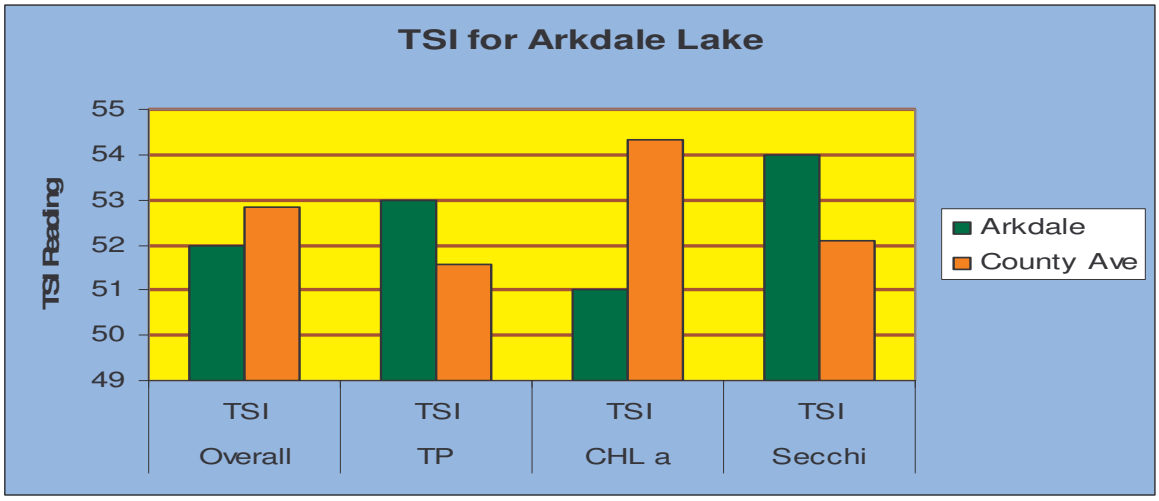
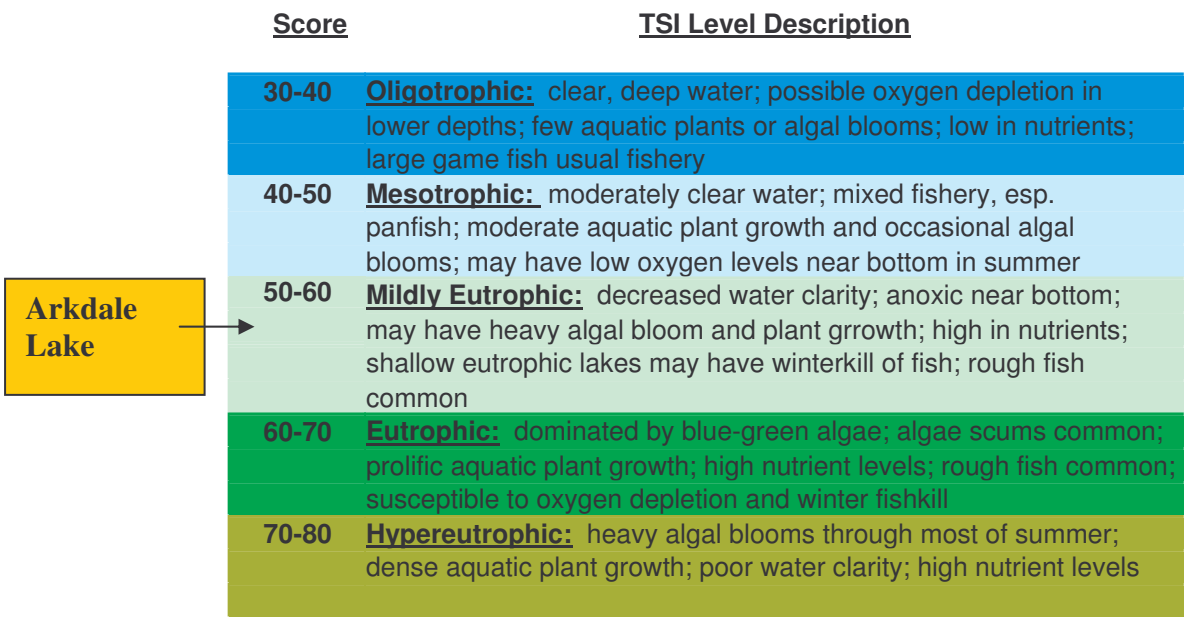


Figure 11: Trophic Status Index Description



A "hydrologic budget" is an accounting of the inflow to, outflow from and storage in a hydrological unit (such as a lake). "Residence time" is the average length of time particular water stays within a lake before leaving it. This can range from several days to years, depending on the type of lake, amount of rainfall, and other factors. In an impoundment like Arkdale Lake, with both an input and outlet, water and its nutrient load tend to move through the lake, rather than spending a long time in it. In Arkdale Lake's case, computer modeling estimates a water residence of **.01 years** (slightly under 4 days).

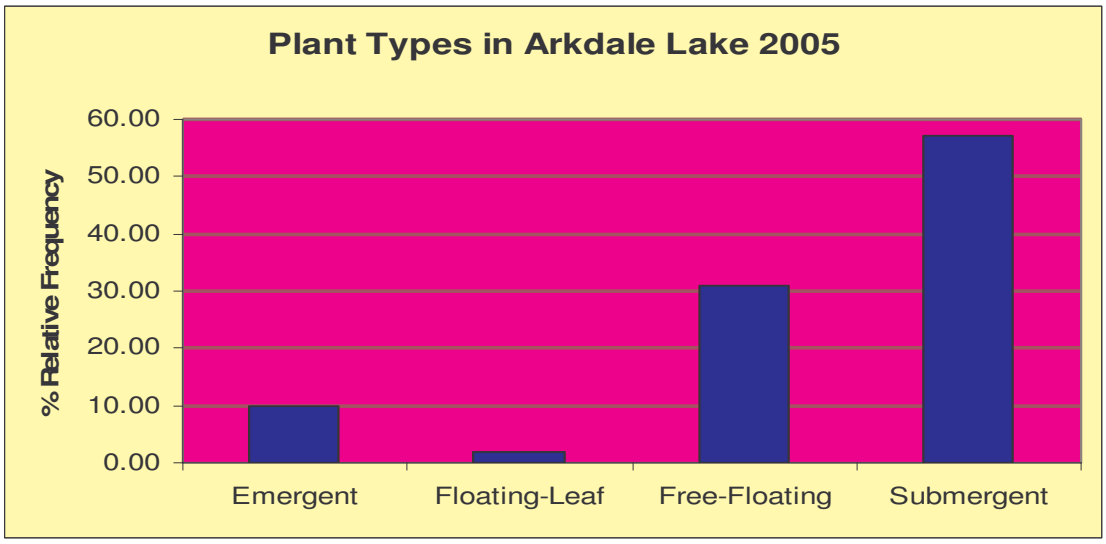
Aquatic Plants

An aquatic plant survey of Arkdale Lake was done in 2005 by Adams County LWCD staff. 16 species were found. This included four emergent species, three free-floating plants, one floating-leaf rooted plans and eight submergent species. One invasive exotic, *Myriophyllum spicatum* (Eurasian watermilfoil), was found at several sites in the lake, with an occurrence frequency of 35.7%. A second invasive exotic, *Potamogeton crispus* (curly-leaf pondweed), was also found, but was infrequently-occurring.

The species with the highest frequency in the 2005 survey was *Vallisneria americana* (water celery). Commonly-occurring native aquatic species included *Lemna minor* (small duckweed); *Potamogeton zosteriformis* (flat-stemmed pondweed); and *Wolffia* spp. (watermeal).

Vallisneria americana was also the densest plant in the lake in 2005. Two others, *Spirodela polyrhiza* (large duckweed) and *Wolffia* spp., both free-floating plants, occurred at more than average densities where present. *Vallisneria americana* was also the dominant aquatic plant in Arkdale Lake in 2005, with *Wolffia* spp. sub-dominant.

Figure 12: Aquatic Plant Types in Arkdale Lake 2005



The Arkdale Lake Association owns a small mechanical harvester. Mechanical harvesting has been performed on a sporadic basis since 1966 without any particular schedule or map. WDNR records indicate that no lakewide chemical treatments have occurred since 1968-1971, although lake resident believe there were some since then. There was a DNR-approved drawdown in the spring of 1988 to attempt to control aquatic plant growth. Lake-front owners noticed no particular decrease in aquatic plant growth; however, they noted a considerable increase in silting in the lake and a negative effect on the fishery from the drawdown. There have been several complaints about the density of aquatic plants and interference with boat traffic. The Lake Association needs to develop of more regular schedule of harvesting for navigational purposes. In 2005, a significant invasive rusty crayfish population was found in Arkdale Lake. There were reports that the rusty crayfish had removed about 1/3 of the aquatic plants in the east end of the lake. Rusty crayfish were reported to be less numerous in 2007.

Figure 13a: Distribution of Emergent Aquatic Plants in Arkdale Lake in 2005

Figure 13b: Distribution of Floating-Leaf Rooted and Free-Floating Aquatic Plants in Arkdale Lake in 2005

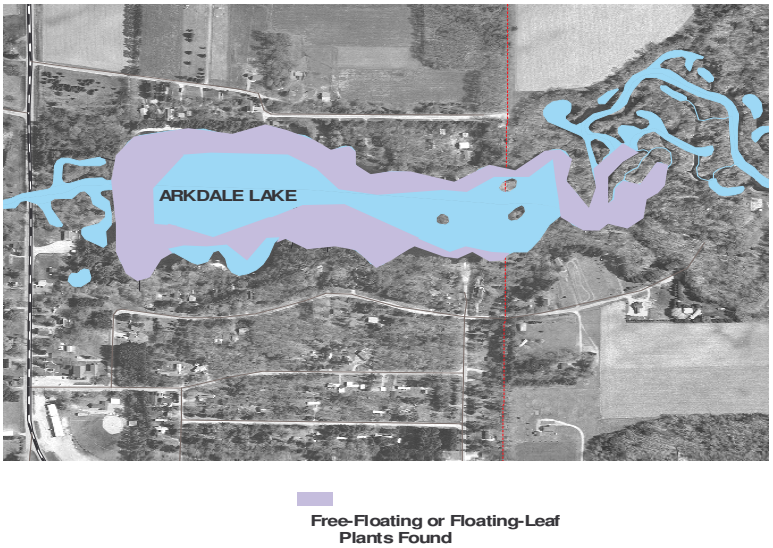


Figure 13c: Distribution of Submergent Aquatic Vegetation in Arkdale Lake in 2005

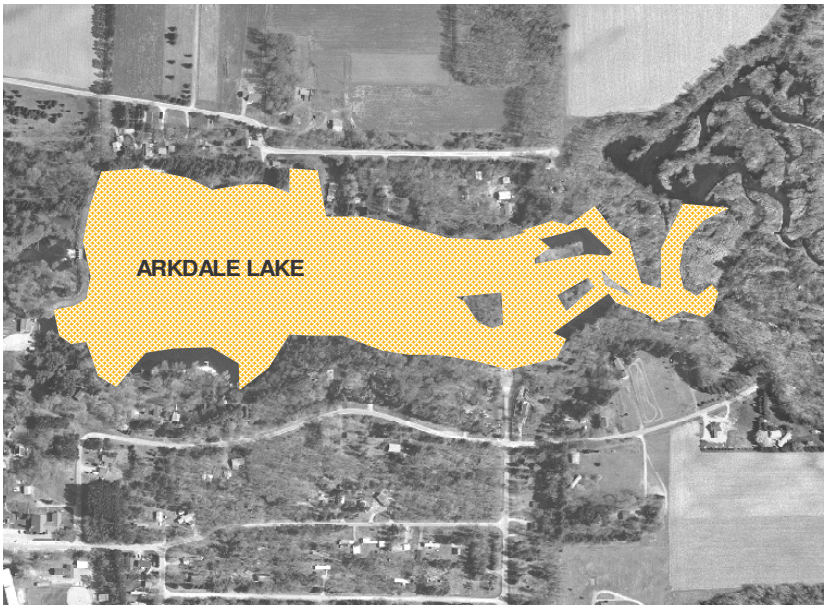


Figure 13d: Distribution of Eurasian Watermilfoil in Arkdale Lake in 2005

Fishery/Wildlife/Endangered Resources

WDNR fish stocking records for Arkdale Lake go back to 1935, when northern pike, bullheads and bass were put into the lake. In 1965, a break of the Arkdale Dam resulted in several hundred dead fish. An evaluation in 1971 determined that the lake was best suited for northern pike, largemouth bass and panfish. A 1995 WDNR survey of Arkdale Lake indicated that northern pike and white sucker were abundant. Yellow perch, black crappie and bluegills were common, but largemouth bass, walleye, spotted suck and pumpkinseed were scarce. Recent reports from lake users express the belief the fishing has declined since the infestation by rusty crayfish. Aquatic plant growth at the eastern end of the lake has declined since that infestation as well. The Lake Management Plan includes steps for diminishing the impact of rusty crayfish.

Seen during the field survey were various types of waterfowl and songbirds. Frogs and salamanders are known, using the lakeshore for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well.

The Arkdale Lake watersheds are home to many endangered resources. Endangered natural communities found in these watersheds include floodplain forest, lake (shallow, hard, seepage), northern sedge meadow, northern wet forest, pine barrens and shrub-carr. Endangered, threatened or special concern plant species found in these watersheds are Crossleaf Milkwort, Engelmann Spikerush, Grassleaf Rush, One-Flowered Broomrape, Slim-stem Small-reedgrass, Whip Nutrush and Yellow Screwstem. Karner Blue Butterfly, Persius Dusky Wing Butterfly and Sand Snaketail Dragonfly, all endangered, threatened or of special concern, are also present in these watersheds.

Shoreline Use and Buffers

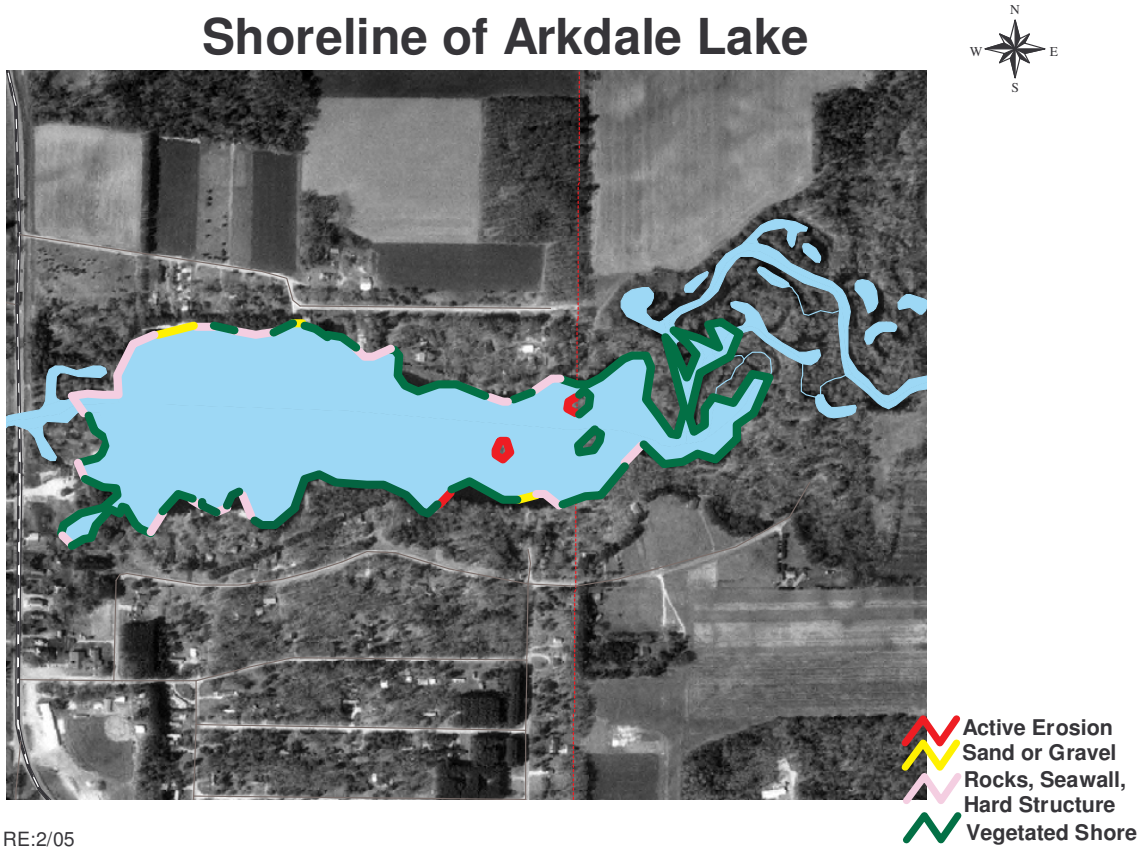
In 2004 and during the aquatic plant survey in 2005, shore surveys were performed. The plant survey revealed that 55.87% of the Arkdale Lake shoreline was covered with disturbance, the rest of the shore is covered with native vegetation. Traditional mowed cultivated lawn dominated the disturbed shores, covering 38.33% of the shore. Other disturbances included rock riprap, seawalls, and bare soil. These types of disturbed shorelines have been found to contribute negatively to water quality. They do not provide food or shelter for wildlife and fish and may degrade spawning beds. They tend to increase runoff and excess nutrients. The lack of plant cover tends to warm the water by disturbed areas, encouraging the growth of algae and nuisance aquatic plants. It will be necessary

for the plan to take steps to maintain the native vegetation and encourage those will lawn to increase native vegetation at their shores.

Shorelands are critical habitat necessary for the protection and enhancement of lake water quality, fisheries, wildlife and aquatic life. They provide shelter and food for wildlife and fish. They support spawning beds, cover and feeding areas for fish and invertebrates. Native vegetation filters and traps pollutants and excess nutrients, preventing them from entering the lake water, thus protecting water quality. They provide significant aesthetic beauty and can also serve as a visual and audio buffer between the shoreland residents and lake traffic or noise.

It is essential to protect and maintain the existing natural shorelands and restore shoreland habitats that have been eliminated or degraded by nearshore development. Natural shorelands contain a mixture of native plants including trees, shrubs, grasses and forbs (wildflowers) that provide critical habitat for water-dependent wildlife and help filter stormwater runoff by removing excessive nutrients and sediments before they reach the lake.

Figure 14: Shoreline Map of Arkdale Map



The 2004 shore survey showed that less than 50% of the shore had an "adequate buffer." An "adequate buffer is as a native vegetation strip at least 35 feet landward from the shore. However, parts of the north shore had an inadequate buffer. Most of the "inadequate" buffer areas were those with mowed lawns and insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.

Shoreland buffers are an important part of lake protection and restoration. These buffers are simply a wide border of native plants, grasses, shrubs and trees that filter and trap soil & similar sediments, fertilizer, grass clippings, stormwater runoff and other potential pollutants, keeping them out of the lake. A 1990 study by the Wisconsin Department of Natural Resources of Wisconsin shorelines revealed that a buffer of native vegetation traps 5 to 18 times more volume of potential pollutants than does a developed, traditional lawn or hard-armored shore. The filtering process and bank stabilization that buffers provide help improve or maintain a lake's water quality and clarity. Vegetated shoreline buffers help stabilize shoreline banks, thus reducing bank erosion. The plants roots give structure to the bank and also increase water infiltration and decrease runoff.

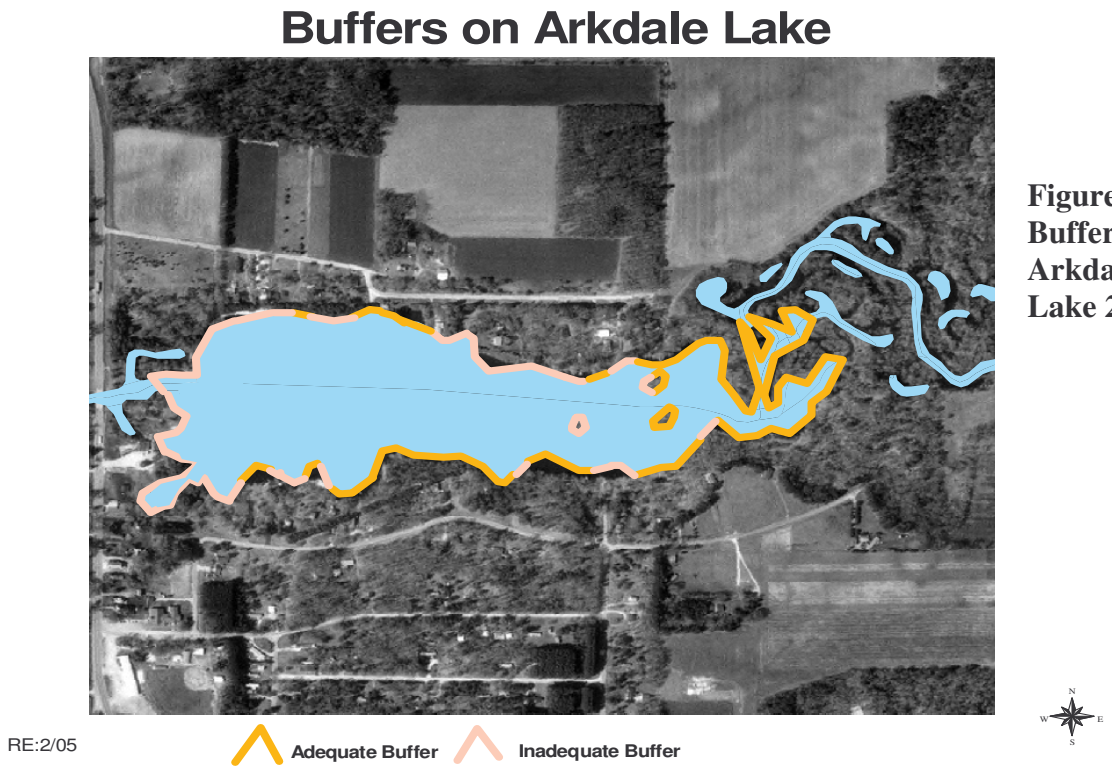
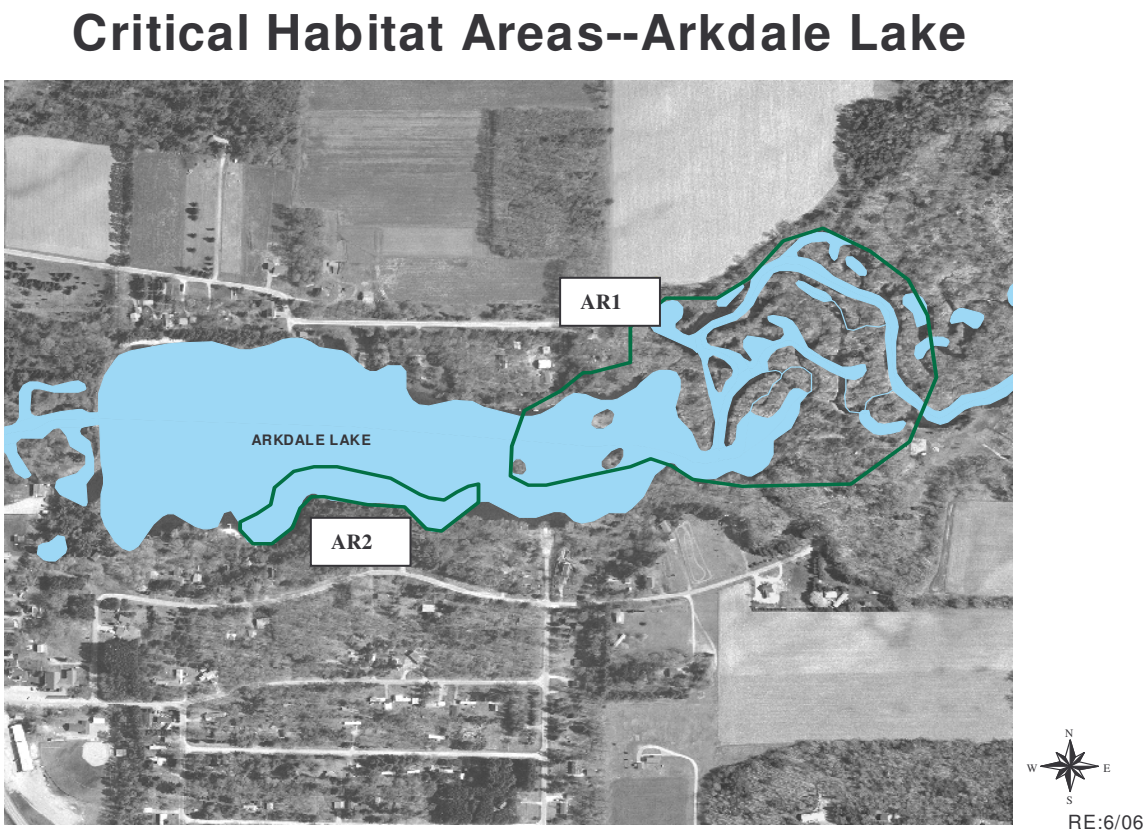


Figure 15: Buffers on Arkdale Lake 2004

Critical Habitat/Sensitive Areas

Under Wisconsin Rule 107.05(3)(i)(I), the Wisconsin DNR can evaluate a lake and declare particular areas of the lake as "sensitive or critical habitat areas." These are defined as "areas of aquatic vegetation offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water." These areas were designated in 2006-2007 and are shown on the following map.

Figure 16: Arkdale Lake Critical Habitat Areas



Two areas on Arkdale Lake were determined to be appropriate for critical habitat designation, based on water quality, fish habitat and wildlife habitat. AR1 extends along the entire northeast end of the lake and the eastern end of the north shore, with an average water depth of less than 2' in the most eastern end and of less than 3' along the north shore. Sediment includes muck, silt and mixtures thereof. 25% of the shore is wooded; 55% is native herbaceous cover and 20% is shrubs. Some woody cover is present for habitat. Six species of emergent aquatic plants, two free-floating species, and six submergent species (including one invasive plant) were found in AR1. Human disturbance impact on this area is currently limited, perhaps partially due to the very shallow waters.

AR2 extends along the 425' of the south shoreline with an average water depth of less than 5'. Sediment includes muck, silt and mixtures thereof. 40% of the shore is wooded; 23% is native herbaceous cover and 35% is shrubs. Some woody cover is present for habitat. This area is a small section of currently undeveloped shore, with development present on both sides of it. Human disturbance impact on this particular area is currently limited. Aquatic species found here included one emergent type, two floating-leaf rooted, three free-floating, and six submergent plant species.